Defining the Distance Between the His Bundle and First Septal Perforator: Implications for Left Bundle Branch Pacing

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Abstract

Introduction: Left bundle branch pacing (LBBP) is a developing method of native conduction pacing, but cases of injury to the septal perforator arteries during implantation have been reported. Knowing the distance between the His bundle and the first septal perforator artery can help operators implant LBBP leads more safely **Methods:** Using previously performed coronary CT angiography (CCTA) studies, the distance between the His bundle and the first septal perforator was measured. **Results:** A total of 50 CCTA studies were included. The mean distance from the His bundle to the first septal perforator (His-SP) along the line connecting the His bundle to the RV apex (His-RV apex) was 27.17 ± 7.7 mm with a range of 13.0 to 44.7 mm. The distance was greater than 2.0 cm in 90% of patients. To standardize this distance among patients with varying cardiac structures, the ratio between the His-SP distance and the His-RV Apex distance was also measured. The mean His-SP:His-RV Apex was 0.302 and the median was 0.298. 86% of patients had a ratio of greater than 0.20. **Conclusion:** Using this information, operators can aim to implant LBBP leads within 2.0 cm of the His bundle or 20% of the distance between the His bundle and the RV apex with minimal risk of causing vascular injury.

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Conclusion: Using this information, operators can aim to implant LBBP leads within 2.0 cm of the His bundle or 20% of the distance between the His bundle and the RV apex with minimal risk of causing vascular injury.

Key Words

Left bundle branch pacing; physiologic pacing; conduction system pacing; coronary CTA; His bundle; septal perforator arteries

Introduction

Left bundle branch pacing (LBBP) is a new and developing method of pacing that uses the patient's native conduction system, with early results showing improved sensing and lower capture thresholds compared to His bundle pacing (1-4). Observational data suggest possible benefits for some patients compared to standard right ventricular (RV) pacing (5), and it is also an option for patients with heart failure and left bundle branch block who need cardiac resynchronization therapy (6, 7). LBBP involves inserting a pacemaker lead from the right ventricle, penetrating the interventricular septum to reach the area of the left bundle branch or one of its fascicles on the left side of the septum (8). A potential complication of LBBP is damage to a septal perforating branch of the left anterior descending coronary artery. A recent report described a transient ST-elevation myocardial infarction via vasospasm of this artery (9). Therefore, determining the optimal lead implantation site is required to ensure the safety and efficacy of LBBP.

Since the lead is inserted distal to the His bundle, and mapping of this can be used to provide a fluoroscopic landmark, knowing the range of distances between the His bundle and the first septal perforator artery would allow operators to choose the site of lead placement more safely and confidently. However, there are few published data regarding this. We reviewed coronary computed tomography angiography (CCTA) studies previously performed at our institution to evaluate this anatomy and define the range of distances between the His bundle and first septal perforator artery so as to guide operators on safe lead placement sites for LBBP.

Methods

Image Selection

Clinically indicated CCTAs previously performed at Temple University Hospital from September 2016 to December 2020 were reviewed. Patients were excluded if the imaging study was inadequate for visualization of the septal perforator artery or right ventricular (RV) apex. Patients with prior coronary artery bypass grafting (CABG) were also excluded to minimize effects of grafting on the localization of the first septal perforator artery.

Data Collection

Through chart review of our institutional electronic medical record, patient's baseline demographic and clinical information was collected. This included sex, age, and relevant medical history. The most recent echocardiography results prior to the date of CCTA were also reviewed and information including ejection fraction, left ventricular diameter and interventricular septum thickness was recorded. All data were stored and managed in a REDCap (Research Electronic Data Capture, Vanderbilt University, Nashville, TN) database.

Imaging Measurements

Images were uploaded to a processing software (Aquarius iNtuition Viewer, TeraRecon, Inc., Durham, NC, version 4.4.13.P7) that allowed for 3-dimensional reconstruction of images and measurements. The intersection of the tricuspid annulus and the base of the non-coronary cusp of the aortic valve represented the location of the His bundle (**Figure 1A**). From there, a line was extended to the RV apex in RAO view to mirror standard clinical conditions (**Figure 1B**). Next, the first septal perforator was identified. The complete course of the artery was not always visible. Therefore, a line connecting the artery ostium to the previously drawn His-RV line was drawn in order to standardize measurements across patients (**Figure 1C**). To ensure standardization, the line was drawn so that it would intersect with the His-RV line at a measured 90-degree angle. Finally, the distance between the previously located His bundle and the intersection of the septal perforator line was measured and recorded (**Figure 1D**).

Statistical Analysis

Values were analyzed using standard statistical methods. T-tests were used for continuous variables. All statistical analyses were done using Microsoft Excel.

Results

A total of 50 consecutive CCTAs were included in this study, 30 men and 20 women. The average age was 55.4 $\pm$ 14.1 years. Medical history included hypertension (64%), diabetes (50%) and CAD (10%). LVH was present in 9 patients (18%) but was mild in all cases. Heart failure was present in 9 patients (18%), 4 of whom had systolic dysfunction with an average EF for the study being 57.0 $\pm$ 8.6 % determined by echocardiography. The mean left ventricular internal diameter at end diastole (LVIDd) and interventricular septum thickness (IVS) were 46.7 mm and 10.2 mm, respectively. The mean distance from the His Bundle to the first septal perforator (His-SP) along the line connecting the His bundle to the RV apex (His-RV apex) was 27.17 $\pm$ 7.7 mm, median 26.9 mm, range 13.0 to 44.7 mm. There was no significant difference by gender for mean distance (28.1 mm in men vs 25.6 mm in women, p=0.26). Given the variability in cardiac structure among patients, this ratio between the His-SP distance and the His-RV Apex distance was also measured. The mean His-SP:His-RV Apex was 0.302 and the median was 0.298. The relationship between the His-SP and the His-RV Apex distances are shown in**Figure 2** . The percentage of patients who met certain distance and ratio cutoffs between the His Bundle and the first septal perforator are shown in **Table 1** .

Discussion

LBBP is a developing method of conduction system pacing that offers several advantages over conventional methods of pacing. However, it can be associated with direct vascular injury to the septal perforator arteries

(9, 10). Therefore, knowing the distance between the His bundle and the first septal perforator artery would help guide operators when performing LBBP insertion.

One study has evaluated the distance from the His bundle to the first septal perforator in the setting of alcohol septal ablation for hypertrophic cardiomyopathy (11). Although the methods are not stated in the paper, it is likely that the authors measured the distance from the His bundle to the ostium of the septal perforator. LBBP leads are implanted more inferiorly, along a line connecting the His bundle to the RV apex, and thus the distance along this line, which is most relevant to LBBP, has not been described.

In this study, CCTAs that were performed for standard indications were retrospectively reviewed and this distance was measured. There was variation in this distance, but it was greater than 1.5 cm in 90% of patients and greater than 2.0 cm in 84% of patients. Therefore, operators should aim to implant a LBBP lead less than 1.5 cm from the His bundle, and if not possible, less than 2.0 cm would have similar safety profile.

There are several limitations to this study. As this was based on CT imaging, it is possible that the first septal perforator artery was not visible because of the resolution of the imaging or timing of contrast. Since the entire course of the septal perforator was often not visible, the measurement was made to a line connecting the artery os to the His-RV apex line at a 90-degree angle. This may not have followed the actual course of the artery in all cases.

Conclusion

The potential benefits of LBBP over conventional pacing make this an exciting new technology, but the risks of coronary artery injury during implantation of LBBP leads is a complication that requires close attention. By knowing the typical distance between the His bundle and the first septal perforator artery as we report in this study, operators can reduce the risk of coronary artery injury when implanting LBBP leads.

Tables/Figures

	Percentage of Patients
His-SP Distance [?] 1.3 cm > 1.5 cm > 2.0 cm	100% 90% 84%
His-SP : His-RV Ratio > 0.15 > 0.20	98% 86%

Table 1: Percentage of patients at different His-SP distance cutoffs and ratio between His-SP distance to His-RV distance.

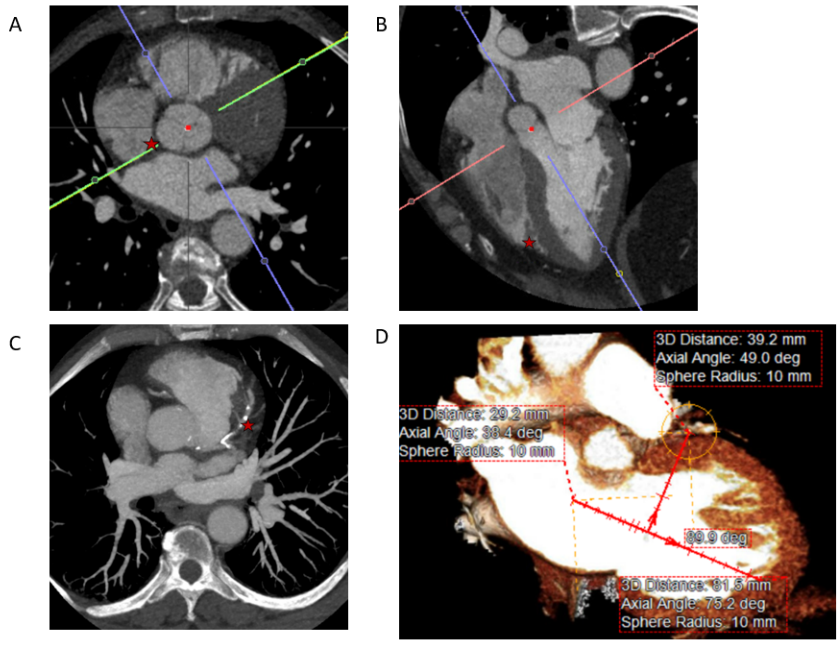

Figure 1: Representative coronary CTA images. A: His bundle located at base of non-coronary cusp of aortic valve, denoted by red star. B: RV apex location, marked by red star. C: First SP os location, marked by red star. D: 3D reconstruction view of measurements in RAO view.

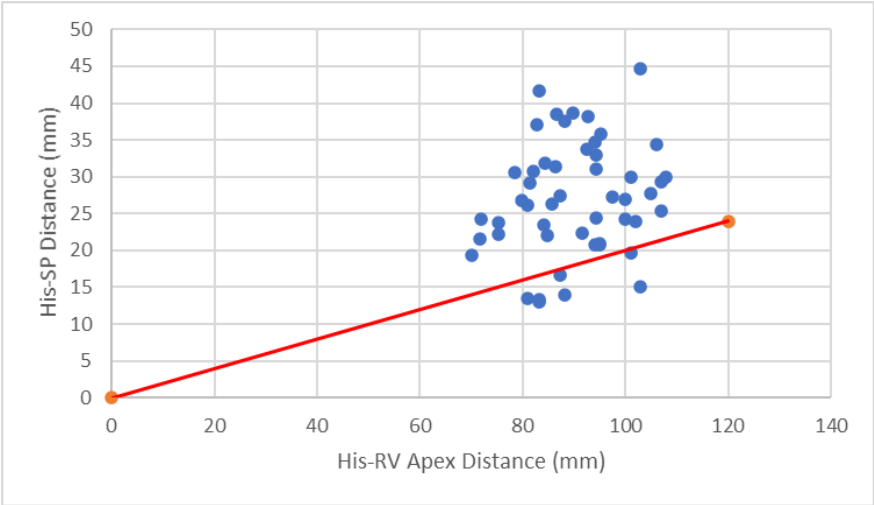

Figure 2: Scatterplot of the relationship between the His-SP distance and the His-RV apex distance. Line represents a ratio of 0.20.

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